A MODEL OF ORGANIZATIONAL DECISION PROCESSES

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THESIS

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ABSTRACT

A review of some of the current thinking pertaining to suboptimization and decentralization is conducted. Ruefli's Generalized Goal Decomposition Model is discussed with emphasis placed upon description of the informational requirements necessary for the iterative process and the constraints necessary for the model to function. The Generalized Goal Decomposition Model is extended to include quadratic deviations from goals. The nature of weighting factors in an organizational context is examined. Some current methods for determining weighting factors for goal programing problems are presented. A goal programing method using a separable objective function for the management level is proposed for determining weighting factors.

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I. INTRODUCTION

The increasing size and complexity that characterize the organizations that are found in almost every facet of our economy make it imperative to understand the manner in which they function. One may be faced with the question of whether or not to allow the organizational levels to retain their current functions more or less unchanged, or to reallocate the functions among the levels, or to strengthen or weaken the powers of the central unit. Before such questions can be answered one must have an understanding of the way an organization works in order to attempt to control or modify the results of the organization. "The choice of a resource allocation mechanism must be made with reference to the class of environments to be covered and in the light of some comparative valuation of the different dimensions of the performance characteristics."[1]

If all aspects impinging upon the organization were known and unchanging and no computational difficulties existed, the problems that the organization faced could be solved without subdividing these problems. If all the aspects of a problem were known, there would be little point in using anything other than a centralized decision procedure. The problems could either be solved by the central unit or passed on to subordinates with explicit instructions which would insure that the solution obtained by the subordinates would, in fact, be the same as that obtained by the central unit. However, objectives do not remain fixed, but evolve through

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[1] Hurwicz, L., "Optimality and Informational Efficiency in Resource Allocation Processes," Mathematical Methods in the Social Sciences, 1959, Arrow, K. J., Karlin, S., and Suppes, P., eds., p. 29, Stanford University Press, 1960.

external effects and experience. In the real world, it is necessary to divide the problems into components that are meaningful according to relevant criteria.[2]

Either suboptimization or decentralization can be utilized when a lack of information and/or conditions of uncertainty exist. According to Smithies [9], suboptimization can be considered as the factoring of the total problem into subproblems. It does not imply any delegation of authority, while decentralization does involve some degree of delegation of decision making authority. Due to its nature, decentralization tends to involve some conflict in the point of view between the central unit and its subordinates.

The conditions for suboptimization parallel the conditions for undertaking decentralization. These are as follows:

1) The total program should be factored into components whose outputs are meaningful for the organization and if possible they should be measurable;
2) There should be no significant interaction between the design of the suboptimized system and the other variables in the system.[3]

With regard to suboptimization, Smithies states further that: "A necessary and sufficient condition for suboptimization with respect to a group of variables of the total system is that the marginal rate of substitution among members of the group is independent of the value of the variables outside the group."[4]

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[2]Smithies, A., "PPBS, Suboptimization and Decentralization,"p. 1, RAND, RM-6178-PR, April 1970.

[3]Ibid., p. 3.

[4]Ibid.

Even though it may not be possible for an organization to strictly meet these conditions, there is still a need for suboptimization in the decision making process. Optimization which includes the use of suboptimization may continue to be utilized with the recognition that lack of information and uncertainty are inherent in the system. Stated in another way, suboptimization maximizes an objective function which is factored out of the total objective function, while decentralization implies maximization of some objective function unique to the decentralized decision maker.[5] The decision maker may approach a given problem more effectively in terms of subproblems because of a lack of information about objective costs and technology. From the knowledge that is gained by dealing with the subproblems, the decision maker gradually builds up a solution.

If there are no conflicts of interest within the organization, decisions can be made by the central unit with suboptimization being used only as a device to assist the decision maker. This is the same as saying that there is full harmony between subordinates and superiors in the organization. However, with decentralization and its accompanying delegation of authority, there may be a risk of giving rise to conflicts of interest. Advocacy positions within the organization produce some divergence of interest between subordinates and superiors.

The approach to a problem can be simplified by reducing the number of externalities affecting its solution; however, the overall objective function usually remains unknown. In order to optimize a given problem, there must first be a knowledge of technological tradeoffs, which is

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[5] Ibid., p. 12.

supposedly determined by the suboptimizers, and there must also be a knowledge of the relative weights that should be allocated to the various criteria. These weights are determined by interactions between the central unit and the subordinates.

There are numerous advantages and disadvantages to decentralization. In decentralization, individuals or groups have more opportunity to exercise initiative; however, a centralized unit may have greater flexibility and quicker response. Decentralization tends to reduce information costs.[6] It also may cause some duplication of effort. All in all the diversity of decentralization may be preferred to the consistent adherence to an objective function which may be incorrect, a situation which is entirely possible under conditions of uncertainty and lack of knowledge.

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[6]Marschak, T., "Centralization and Decentralization in Economic Organizations," Econometrica, Vol. 27, No. 3, p. 400, July 1959.

II. GENERALIZED GOAL DECOMPOSITION MODEL WITH LINEAR DEVIATIONS

The way in which elements are organized in great part determines the solution. Ruefli [7] has shown this in his Generalized Goal Decomposition Model. Buchanan [1] says essentially the same thing when he states that costs/benefits vary over different organizations because who determines these factors varies. Crecine [2] reinforces Buchanan's point in a counter example. He shows that even though the DOD planning process has changed to programs, the budgetary decisions (which drive the system) are made by the same persons, so the solutions generated have much in common over the years.

As mentioned above, T. W. Ruefli has proposed a model of a decision making organization where the solutions depend upon the structure of the organization.[7] His model is structure dependent and goal oriented. It involves a three level organization where his intermediate units or management units allow the central unit to evaluate its goal generating policies while they guide the alternative generation activities of the operating unit level. (See Fig. 1.)

The management units solve a resource allocation problem stated in goal programing form in which each management unit minimizes the weighted sum of deviations from the goals. The weights are determined a priori. The following formulation delineates the management units' problem, with symbols employed as stated.

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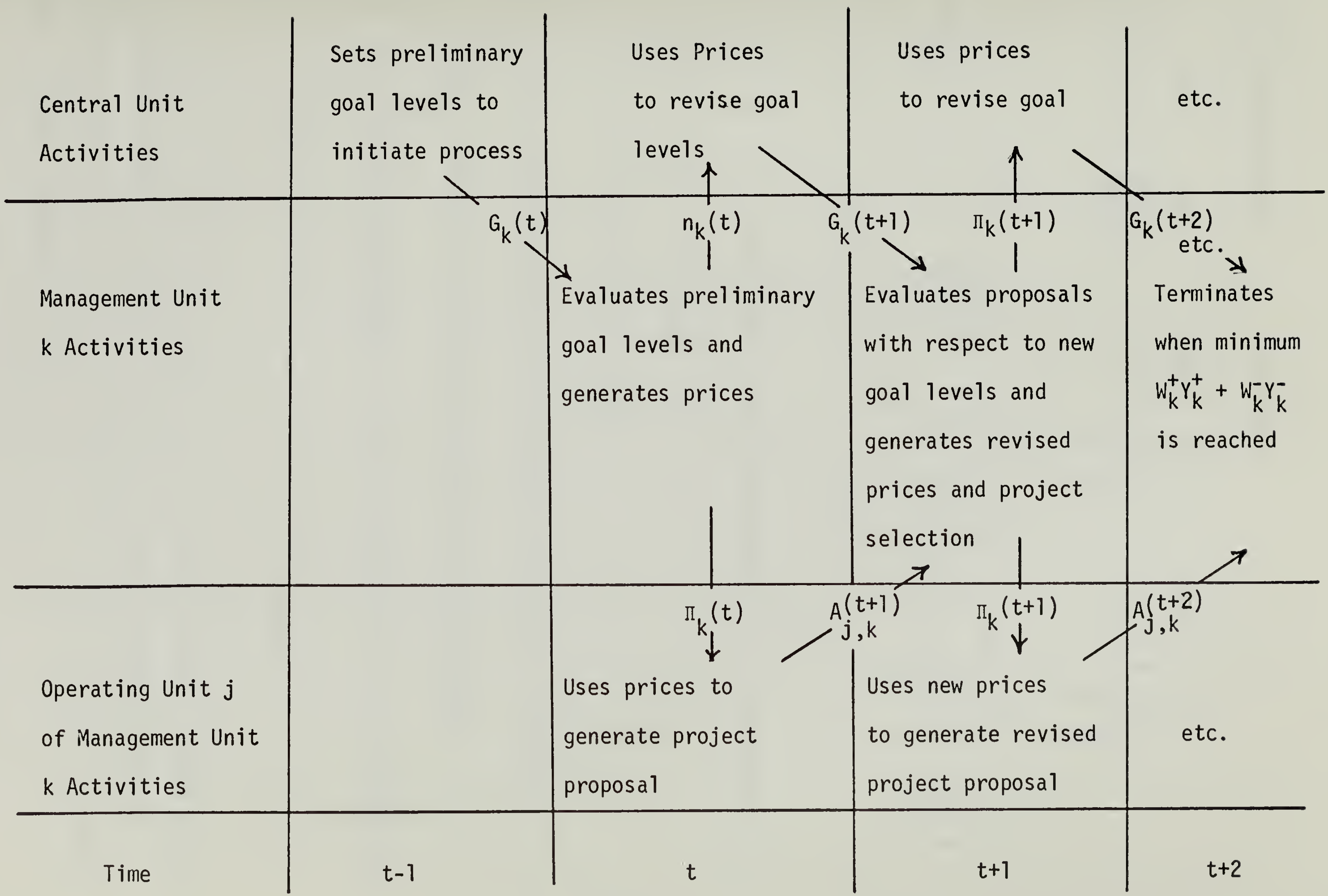
[7]Ruefli, T. W., "A Generalized Goal Decomposition Model," Management Science, Vol. 17, No. 8, p. B-513, April 1971.



Central Unit Activities
Sets preliminary goal levels to initiate process
Uses Prices to revise goal levels
Uses prices to revise goal
etc.
$G_k(t)$
$n_k(t)$
$G_k(t+1)$
$\Pi_k(t+1)$
$G_k(t+2)$
etc.
Management Unit k Activities
Evaluates preliminary goal levels and generates prices
Evaluates proposals with respect to new goal levels and generates revised prices and project selection
Terminates when minimum $W_k^+Y_k^+ + W_k^-Y_k^-$ is reached
$\Pi_k(t)$
$A_{j,k}^{(t+1)}$
$\Pi_k(t+1)$
$A_{j,k}^{(t+2)}$
Operating Unit j of Management Unit k Activities
Uses prices to generate project proposal
Uses new prices to generate revised project proposal
etc.
Time
t-1
t
t+1
t+2

FIGURE 1

k^{th} management unit (Primal)

$$\min \underset{1\times n_k}{[0,\ldots,0]} \underset{n_k\times 1}{\begin{bmatrix} x_k^T \end{bmatrix}} + \underset{1\times m}{[W_k^+]} \underset{m\times 1}{\begin{bmatrix} Y_k^+ \end{bmatrix}} + \underset{1\times m}{[W_k^-]} \underset{m\times 1}{\begin{bmatrix} Y_k^- \end{bmatrix}}$$

$$\text{subject to } \underset{m\times n_k}{\begin{bmatrix} A_k \end{bmatrix}} \underset{n_k\times 1}{\begin{bmatrix} x_k^T \end{bmatrix}} - \underset{m\times m}{\begin{bmatrix} I_{m_k} \end{bmatrix}} \underset{m\times 1}{\begin{bmatrix} Y_k^+ \end{bmatrix}} + \underset{m\times m}{\begin{bmatrix} I_{m_k} \end{bmatrix}} \underset{m\times 1}{\begin{bmatrix} Y_k^- \end{bmatrix}} = \underset{m\times 1}{\begin{bmatrix} G_k \end{bmatrix}}$$

$$0 \leq x_{j,k} \leq 1 \qquad Y_k^+,\ Y_k^- \geq 0$$

$j = 1,\ldots,n_k$ operating units subordinate to the k^{th} management unit

$k = 1,\ldots,M$ management units

$G_k \equiv$ Vector of Resources (Goals)

$Y_k^+, Y_k^- \equiv$ Vectors of Positive and Negative Deviations from Goals.

$W_k^+, W_k^- \equiv$ Weights for Positive and Negative Goal Deviations.

$A_k \equiv$ Matrix of Attributes of Project Proposals for all n_k subordinate operating units.

$x_k \equiv$ Vector of Activity Levels for Project Proposals.

Ruefli utilizes the following dual problem to generate "shadow prices." A negative shadow price means that the particular management unit has failed to meet a goal. A positive shadow price indicates that the management unit has exceeded the goal.

k^{th} management unit (Dual)

$$\max \underset{(\text{fixed})}{\overset{1\text{x}m}{\left[\; G_k^T \;\right]}} \; \underset{(\text{Variable})}{\overset{m\text{x}1}{\begin{bmatrix} \Pi_k \end{bmatrix}}}$$

subject to

$$\overset{n_k\text{x}m}{\begin{bmatrix} A_k^T \end{bmatrix}} \overset{m\text{x}1}{\begin{bmatrix} \Pi_k \end{bmatrix}} \leq \overset{n_k\text{x}1}{\begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix}}$$

$$-\overset{m\text{x}m}{\begin{bmatrix} I_{m_k} \end{bmatrix}} \overset{m\text{x}1}{\begin{bmatrix} \Pi_k \end{bmatrix}} \leq \overset{m\text{x}1}{\begin{bmatrix} W_k^{T+} \end{bmatrix}}$$

$$\overset{m\text{x}m}{\begin{bmatrix} I_{m_k} \end{bmatrix}} \overset{m\text{x}1}{\begin{bmatrix} \Pi_k \end{bmatrix}} \leq \overset{m\text{x}1}{\begin{bmatrix} W_k^{T-} \end{bmatrix}}$$

Π_k unrestricted

$\Pi_k < 0$ failed to meet goals

$\Pi_k > 0$ exceeded goals

Shadow prices are passed up and down by management units. These shadow prices are the inputed value of the goal constraints. Operating units generate alternative proposals for their superior management unit in response to the "shadow prices" generated by the management unit. This is illustrated by the following formulation:

j,kth operating unit

$$\min \underset{\substack{(\text{fixed})}}{\overset{1\times m}{\left[\ \Pi_k^T\ \right]}} \overset{m\times 1}{\left[A_{j,k} \right]}$$

$$\text{subject to} \quad \underset{(\text{Technology})}{\overset{N_{j,k}\times m}{\left[D_{j,k} \right]}} \underset{(\text{Proposal})}{\overset{m\times 1}{\left[A_{j,k} \right]}} \geq \underset{(\text{Stipulations}) \text{ or } (\text{Minimum Output Levels})}{\overset{N_{j,k}\times 1}{\left[F_{j,k} \right]}}$$

$$A_{j,k} \geq 0$$

The central unit generates goals that maximize the inputed values of goals as determined by all management units subject to resource constraints. The formulation is as follows:

Central Unit

$$\max \sum_{k=1}^{M} \underset{(\text{fixed})}{\overset{1\times m}{\left[\ \Pi_k^T\ \right]}} \underset{(\text{Variable})}{\overset{m\times 1}{\left[G_k \right]}}$$

$$\text{subject to} \quad \sum_{k=1}^{M} \overset{M_o\times m}{\left[P_k \right]} \overset{m\times 1}{\left[G_k \right]} \leq \overset{M_o\times 1}{\left[G_o \right]}$$

$$G_k \geq 0$$

G_o is a M_ox1 vector of resource constraints

As can be seen the goal levels are not fixed throughout the problem. The central unit modifies its goals based on information that the management units provide in terms of shadow prices. This can be considered as functioning like a type of feedback system so that goals (allocations) can be challenged or changed. Shubik maintains that this is of importance in a functioning decentralized organization.[8]

It is important to remember that shadow prices are variables for the management units while they are considered fixed by the central unit and operating units. The process described continues until the management units' weighted deviations are at a minimum and no readjustment of goal levels by the central unit or modification of proposals by the operating units will decrease the weighted deviations from the goals for the whole organization. However, activity levels goals and preemptive goals must be communicated at the start in order for the model to function.

Ruefli makes many assumptions concerning externalities. If externalities exist between operating units under the same management unit, then these externalities are contained in the objective function of the management unit. If the externalities exist between management units, the externalities are contained in the objective function of the central unit. If externalities are present between operating units under different management units, the central unit passes down upper limits on goal levels in the initial conditions.[9]

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[8]Shubik, M., "Budgets in a Decentralized Organization with Incomplete Information," p. 4, RAND, P-4514, December 1970.

[9]Ruefli, op. cit., p. B-512.

Ruefli shows that without technology or goal dependencies the system will converge to the optimum (in a goal programing sense) in a finite number of steps. If the dependencies are present, the system may cycle. If externalities are present, we cannot insure that the model will converge in a finite number of steps. In fact one cannot guarantee that cycling will be the worst the model will do. It may diverge indefinitely.[10] Therefore, the levels of the organization are assumed to be horizontally independent.

The following is a general idea of what Ruefli's model is doing during iterations. An understanding of this interplay between levels is necessary to see the relevance of the model to organizational functioning.

The central unit initiates the procedure by giving each management unit prospective indices. Each initial index contains information about production or resource goals which probably reflects current operating conditions and a "best guess" in forecasting goal levels.

The management units generate shadow prices where a negative shadow price indicates that the management unit has failed to meet a goal level for that particular component of the goal vector. A positive shadow price indicates that a goal level has been exceeded.

The central unit attempts to lessen the deviation from the goals at the management level by trying to raise the goal levels for goals that have been exceeded by the management units and by trying to lower the goal levels for the goals the management units have failed to meet.

On the other hand, the operating units try to lessen the deviation from the goals by generating proposals that better meet the goals for goal levels that are not met, and proposals that reduce the production of goal

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[10] Ruefli, T. W., "Behavioral Externalities in Decentralized Organizations," Management Science, Vol. 9, No. 5, p. B-652, June 1971.

levels for those that have exceeded the desired goal levels. In other words, if a goal level is exceeded, the central unit raises the goal level and the operating units lower the goal production. If a goal level is not met, the central unit lowers the goal level, and the operating unit increases goal production. In this manner both the superordinate and the subordinate units are attempting to reduce the weighted goal deviation of the management units.

Ruefli places no restrictions upon the weightings that are assigned a priori to the deviations from the goals. However, in order to have the organization function with any degree of harmony or consensus of purpose, some restrictions are needed. If a management unit really desired to over-produce a certain goal or set the goal at the "correct" higher level, it would assign a negative value to the weighting of the positive deviation (W_k^+),

In this manner, it would minimize the weighted sum of the goal deviations by exceeding the one goal level by as much as possible. Such behavior in an organization would not be tolerated for long. The model itself handles this "problem" in a unique manner. The assignment of a negative value to W_k^+ would cause the lower bound of the shadow price (Π_k) to always be a positive number if the problem was feasible. The last two groups of constraints in the dual formulation help to define the feasible region for Π_k.

$$-\Pi_k \leq W_k^+$$

or

$$\Pi_k \geq -W_k^+$$

if W_k^+ has a negative value, then it can be seen that Π_k is restricted to a nonnegative value.

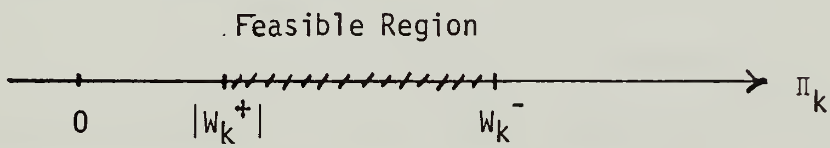
The weighting factor for the negative deviation (W_k^-) would determine the following bound :

$$\Pi_k \leq W_k^-$$

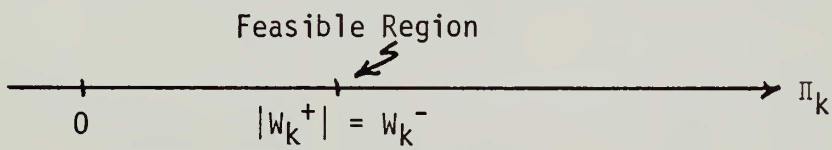
(W_k^- is assumed to be a positive value in the context of the management trying to overproduce this particular goal.)

Three cases result from this "unorthodox" behavior :

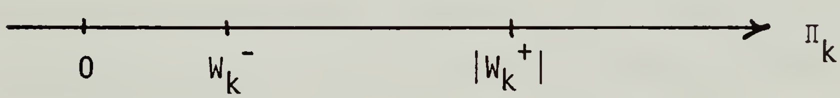
Case I: $|W_k^+| \leq W_k^-$



Case II: $|W_k^+| = W_k^-$



Case III: $|W_k^+| > W_k^-$



In Case III, it can be seen that no feasible region for Π_k exists since a value for Π_k cannot simultaneously be $<k$ and $>k + \varepsilon$. So if W_k^+ were assigned a negative value such that $|W_k^+| > W_k^-$, the model would not function since there would be no feasible value for Π_k, i.e. the constraints would not be consistent.

It is obvious in Case I and Case II that the only possible values for Π_k are positive. This would get a higher goal level from the central unit,

but would cause the operating units to reduce the production of this goal to a minimum because it would always perceive that the management unit was overproducing that particular goal. If the management unit assigned a value of zero to a weighting factor, this would mean that deviations in a particular direction from a prescribed goal were unimportant. And as such, the goal level would cease to function except as either an upper or lower bound. If both positive and negative deviations were weighted zero then that particular goal would cease to exist altogether in the context of this model. In most cases, this type of behavior from a subordinate would hinder an organization.

A similar argument can be made for the assignment of a negative value to the weighting factor for negative deviations (W_k^-). The view of the management unit would be to underproduce the particular goal level as much as possible.

It shall be assumed that $W_k^+, W_k^- \geq 0$ and $W_k^+ + W_k^- \neq 0$. In this way the central unit has a system where management units are encouraged to further the interests of the organization, and, at the same time, are constrained from impairing its interests. It is possible to express a goal as an acceptable range of goal level production. This "goal" would be expressed in two portions. The lower bound would have $W_k^- > 0$; $W_k^+ = 0$. The upper bound would have $W_k^- = 0$; $W_k^+ > 0$. Levels of proposals that provide production of the goal between the upper and lower bounds would provide zero goal deviation for that particular portion of the goal vector.

III. GENERALIZED GOAL DECOMPOSITION MODEL WITH QUADRATIC DEVIATIONS

We have seen how the Generalized Goal Decomposition Model functions using a linear relationship to determine the goal deviations at the management unit level. However, the management units may view large deviations as much more unsatisfactory than smaller deviations. A possible model for this point of view would be to consider the measure of the deviations as a quadratic function as opposed to the linear function Ruefli uses in his model.

This change of viewpoint can be seen in the following formulation of the primal and dual problems at the management unit level. As will be shown, there is no necessity to change the formulation at the central unit or operating unit levels because the shadow prices the management unit sends up and down still reflect whether the particular management unit has exceeded a goal or failed to meet a goal. Only the manner in which deviations are measured has changed.

Hadley [3] shows that the primal and dual problems can be constructed in the following manner:

Primal:

Maximize $\overline{cx} + \overline{x}'\overline{Dx}$

subject to $\overline{Ax} = \overline{b}$

$\overline{x} \geq \overline{0}$

Dual:

Minimize $-\overline{x}'\overline{Dx} + \overline{\lambda}'\overline{b}$

subject to $-2\overline{Dx} + \overline{A}'\overline{\lambda} \geq \overline{c}'$

$\overline{x} \geq \overline{0}$

The quadratic goal deviation formulation can be changed to a minimization problem in the following manner:

$$\min f(x) \quad = \quad - \max -f(x)$$

Utilization of the negative of $\overline{C}$ and $\overline{D}$ will be tantamount to working a quadratic minimization problem which is what is desired. Since the problem is to minimize $\sum_{i=1}^{n} W_i^-(Y_i^-)^2 + W_i^+(Y_i^+)^2$ for a particular management unit (where $W_i^{\pm}$ are the weighting factors for the positive and negative deviations and $Y_i^{\pm}$ are those deviations), it can be seen that $\overline{C} = \overline{0}$.

$\overline{X}$ in Hadley's formulation is equivalent to $(\overline{x}, Y_k^+, Y_k^-)$ in the quadratic goal deviation formulation.

Primal:

$$\text{Maximize} \quad \underset{1 \times n_k+2m}{[0,\ldots,0]} \quad \underset{n_k+2m \times 1}{\begin{bmatrix} x \\ Y_k^+ \\ Y_k^- \end{bmatrix}} \quad +$$

$$\underset{1 \times n_k+2m}{[x \quad Y_k^+ \quad Y_k^-]} \quad \underset{n_k+2m \ \times \ n_k+2m}{\left[\begin{array}{c|c|c} \begin{matrix} n_k \times n_k \\ 0 \end{matrix} & \multicolumn{2}{c}{\begin{matrix} n_k \times 2m \\ 0 \end{matrix}} \\ \hline \begin{matrix} m \times m \\ 0 \end{matrix} & \begin{matrix} -W_1^+ & & 0 \\ & \ddots & \\ 0 & & -W_m^+ \end{matrix} & \begin{matrix} m \times m \\ 0 \end{matrix} \\ \hline \multicolumn{2}{c|}{\begin{matrix} m \times 2m \\ 0 \end{matrix}} & \begin{matrix} -W_1^- & & 0 \\ & \ddots & \\ 0 & & -W_m^- \end{matrix} \end{array}\right]} \quad \underset{n_k+2m \times 1}{\begin{bmatrix} x \\ Y_k^+ \\ Y_k^- \end{bmatrix}}$$

subject to

$$\overset{m \times n_k+2m}{\left[\begin{array}{c:c:c} \overset{m \times n_k}{A_{j,k}} & \overset{m \times m}{-I_{m_k}} & \overset{m \times m}{I_{m_k}} \end{array}\right]} \overset{n_k+2m \times 1}{\begin{bmatrix} x \\ Y_k^+ \\ Y_k^- \end{bmatrix}} = \overset{m \times 1}{\begin{bmatrix} G_k \end{bmatrix}}$$

$$Y_k^+ \text{ , } Y_k^- \geq 0$$

$$0 \leq x \leq 1$$

Dual:

$$\text{Min } -\overset{1 \times n_k+2m}{[x \quad Y_k^+ \quad Y_k^-]} \overset{n_k+2m \times n_k+2m}{\left[\begin{array}{c:c:c} 0 & \multicolumn{2}{c}{0} \\ \hdashline 0 & \begin{matrix} -W_1^+ & & 0 \\ & \ddots & \\ 0 & & -W_m^+ \end{matrix} & 0 \\ \hdashline \multicolumn{2}{c:}{0} & \begin{matrix} -W_1^- & & 0 \\ & \ddots & \\ 0 & & -W_m^- \end{matrix} \end{array}\right]} \overset{n_k+2m \times 1}{\begin{bmatrix} x \\ Y_k^+ \\ Y_k^- \end{bmatrix}} +$$

$$\overset{1 \times m}{[\ \Pi_k\ ]} \qquad \overset{m \times 1}{\begin{bmatrix} G_k \end{bmatrix}}$$

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subject to

$$-2 \overset{n_k+2m \times n_k+2m}{\left[\begin{array}{c:c:c} 0 & \multicolumn{2}{c}{0} \\ \hdashline 0 & \begin{matrix} -W_1^+ & & 0 \\ & \ddots & \\ 0 & & -W_m^+ \end{matrix} & 0 \\ \hdashline \multicolumn{2}{c:}{0} & \begin{matrix} -W_1^- & & 0 \\ & \ddots & \\ 0 & & -W_m^- \end{matrix} \end{array}\right]} \overset{n_k+2m \times 1}{\begin{bmatrix} x \\ Y_k^+ \\ Y_k^- \end{bmatrix}} +$$

$$\overset{n_k+2m \times m}{\begin{bmatrix} A_{j,k} \\ \hdashline -I_{m_k} \\ \hdashline I_{m_k} \end{bmatrix}} \overset{m \times 1}{\begin{bmatrix} \Pi_k \end{bmatrix}} \geq \overset{n_k+2m \times 1}{\begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix}}$$

$$Y_k^+ , Y_k^- \geq 0$$

$$0 \leq x \leq 1$$

Π_k unrestricted

where

x	is $n_k x1$ vector of activity levels.
Y_k^+	is mx1 vector of positive deviation.
Y_k^-	is mx1 vector of negative deviations.
$\begin{bmatrix} -W_1^+ & & 0 \\ & \ddots & \\ 0 & & -W_m^+ \end{bmatrix}$	is mxm matrix with the negative of the weighting factors for the positive deviations along the diagonal and zero elsewhere.
$\begin{bmatrix} -W_1^- & & 0 \\ 0 & \ddots & \\ & & -W_m^- \end{bmatrix}$	is mxm matrix with the negative of the weighting factors for the negative deviations along the diagonal and zero elsewhere.
$A_{j,k}$	is a mxn_k matrix where each column is a proposal from one of the n_k subordinate operating units.

G_k is a mx1 vector of goals.

Π_k is a mx1 vector of shadow prices.

I_{m_k} is a mxm identity matrix.

As can be seen by the dual formulation the objective function contains both the inputed value of the goals and a function of the deviations. This change of point of view says that the management unit will pick as optimum the minimum value of the weighted sum of the deviations squared plus the inputed value of the goals, subject ot constraints on Π_k which are $2Y_k^{\pm}$ times the weighting factor as opposed to just the weighting factor in the linear model.

However, the shadow prices determined in the dual problem measure the same thing as in the linear formulation, i.e. a positive value means that a goal level has been exceeded while a negative value for a shadow price means that a goal level has not been met.

The central unit and operating units would use this information (the shadow prices) in the same manner as in the linear formulation and modify the goal levels and proposals in attempting to assist the management units to further minimize the deviations from the goals.

Both the linear and quadratic formulation of the management units' problem would cause the organizational model to function in the same way. Only the method by which deviations are measured has changed.

IV. DISCUSSION OF WEIGHTING FACTORS AND GOALS

Ruefli's Generalized Goal Decomposition Model provides a descriptive insight into the multilevel decentralized organization. But it has been seen that the solution determined by the model is not only structure dependent but is also a function of the weights assigned to the deviations. In the model the weights are determined *a priori*. In order to increase the generalization of Ruefli's model, the next logical step is to determine some method for obtaining the weighting factors.

Before attempting to determine a suitable method for fixing the weighting factors, it is first necessary to understand the nature of both those weighting factors and the goal levels found in the model. Optimization first involves knowledge of technology tradeoffs which the suboptimizer is supposed to learn through understanding of his own sphere of interest. The relative weights must also be known. They must be determined by empirical or implicit processes involving interactions between the central unit and the management units.

A typical Dissatisfaction-Deviation diagram can be seen in Figure 2. The slope of the line is equivalent to the weighting factor for positive deviations, W_k^+. For the weighting factor for negative deviations, W_k^-, the line would be to the left of the vertical.

In order to perceive the characteristics of a goal level in the model, one must know what purpose the goal level is to serve, or what information it is to provide. Goals in the model can be placed into one of four categories according to the desired result of the goal.

1. Lower Bounds: The "goal" in the model specifies the lower bound for a specified goal's production. The weighting factor for positive

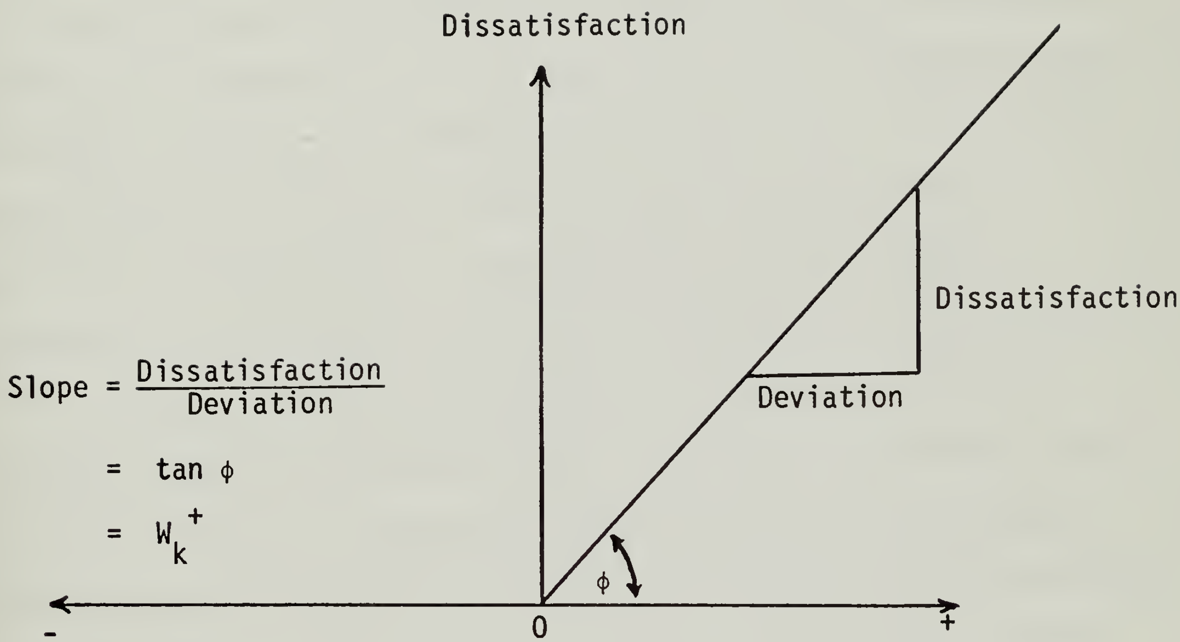
Dissatisfaction
Dissatisfaction
Slope = Dissatisfaction / Deviation
= tan φ
= W_k^+
Deviation
φ
-
0
+

Figure 2

deviations is assigned a value of zero ($W_k^+ = 0$), while the weighting factor for negative deviations has some positive value ($W_k^- > 0$). Production of this goal at the goal level or greater is synonymous with meeting the goal. Underproduction of the goal would be penalized by causing an increase in the weighted sum of goal deviations. (See Figure 3.)

2. Upper Bounds : The "goal" in the model specifies the upper bound for a particular goal's production : the weighting factor for positive deviations has some positive value ($W_k^+ > 0$), while the weighting factor for negative deviations is assigned a value of zero ($W_k^- = 0$). Production of this goal at the goal level or lower is synonymous with satisfying the goal exactly. Overproduction of the goal would be penalized and underproduction would not be penalized. (See Figure 3.)

3. Acceptable Range: The "goal" in the model would specify an acceptable range for a particular goal's production. In order to specify this type of goal it is necessary to combine the first two goal types, upper bound and lower bound. For this goal, two goal levels are required. One goal level such that $G_{k_L} < G_{k_U}$ and $W_{k_L}^- > 0$ and $W_{k_L}^+ = 0$ would set the lower bound. G_{k_U} with $W_{k_U}^- = 0$ and $W_{k_U}^+ > 0$ would set the upper bound. Production of the goal anywhere in the interval $[G_{k_L}, G_{k_U}]$ would be synonymous with meeting the goal exactly. Goal production less than the lower bound or greater than the upper bound would be penalized.

4. Exact Goal Level Specification: The "goal" in the model would specify the exact level for the goal production. Any deviation from this level would incur a penalty in the form of the increased weighted sum of the deviations for the management unit. This type of goal can be characterized as one in which both W_k^- and W_k^+ would be greater than zero.

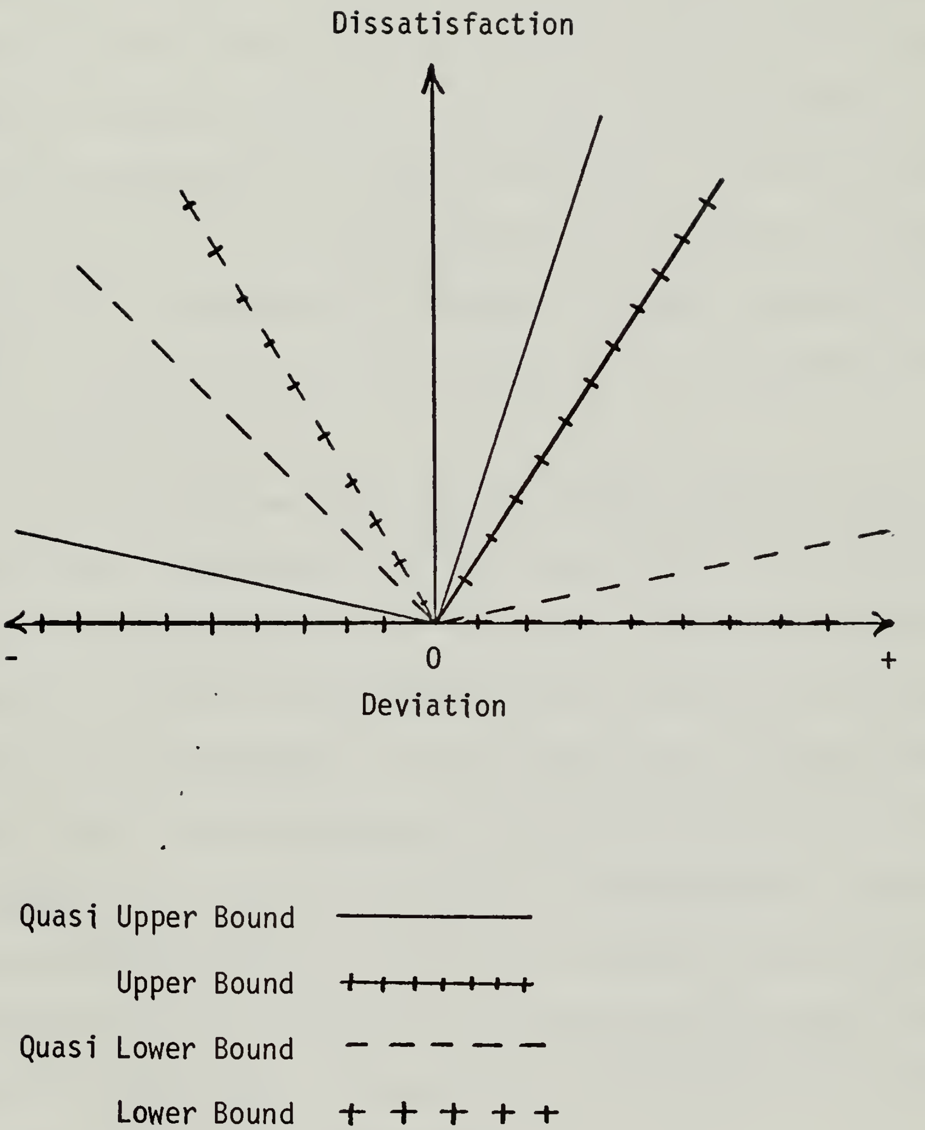
Dissatisfaction
-
0
+
Deviation
Quasi Upper Bound
Upper Bound
Quasi Lower Bound
Lower Bound

Figure 3

The weighting factors (actually the values assigned to the positive and negative weighting factors) are a measure of two aspects about the goal levels. The first aspect the weighting factors measure is the "importance" or priority of the goal for the organization. The more important the goal or the higher the priority of the goal, the larger the relative weights W_k^- and W_k^+. The larger weighting factors tend to minimize the deviation from a higher priority goal. What the weighting factors actually do is tell the management unit how much of a penalty is incurred when a goal level is violated. The more important the goal the higher the penalty for failing to meet it or overproducing this goal. (See Figure 4.)

If the problem were such that at a particular iteration goal levels could not be met, the weighting factors would indicate the relative preference the organization has for which goals are to be underproduced by how much. The lower priority goals with the smaller W_k^-'s would be the first to be underproduced. If the problem were structured such that goal levels were overproduced, the weighting factors would indicate the organization's relative preference for overproduction. A case may arise where the satisfying of a particular goal may cause underproduction of a second goal, while satisfying the second goal may require overproduction of the first goal. The appropriate weighting factors would indicate the organization's preference.

Whenever a goal level has been specified exactly, the weighting factors measure a second aspect. This can be defined as the "accuracy" of the goal level: $W_k^- / W_k^+ = 1$ carries the idea that the goal level, G_k, is accurate. Over or under-production are both equally unsatisfactory, since failure to meet the goal exactly is penalized the same regardless

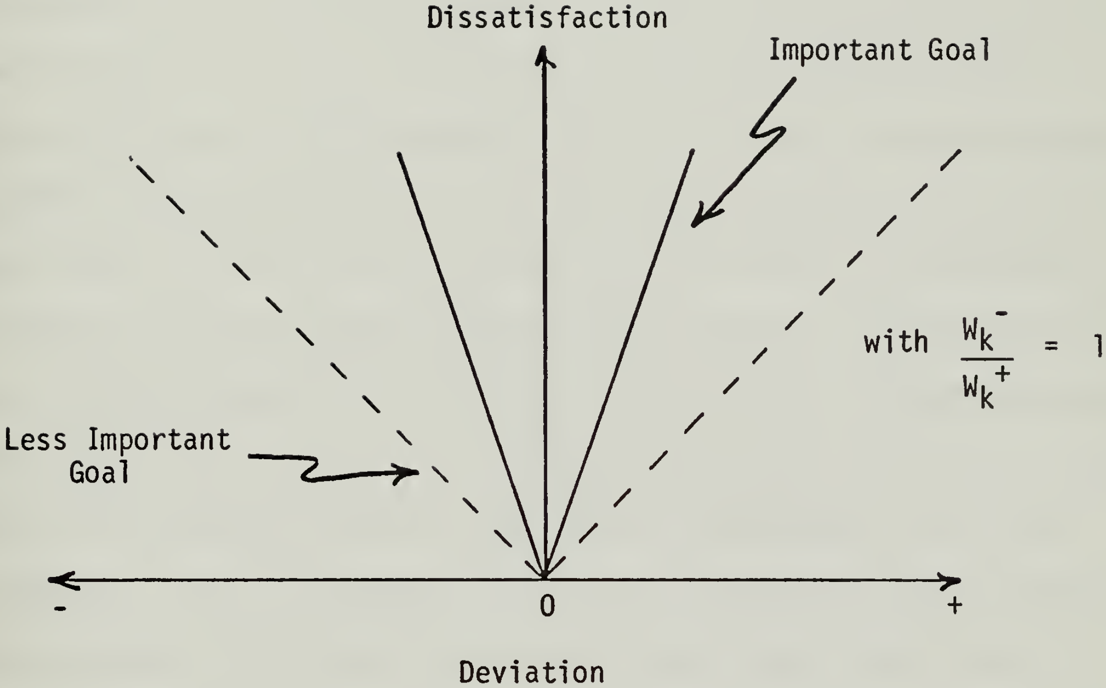
Dissatisfaction
Important Goal
with $\frac{W_k^-}{W_k^+} = 1$
Less Important Goal
-
0
+
Deviation

Figure 4

of the direction of the deviation. A goal level has been set accurately if $W_k^- = W_k^+$. (See Figure 4.)

$W_k^-/W_k^+ < 1$ carries the idea that the goal level has not been accurately set because the management unit will be penalized more for positive deviations than for negative deviations. The goal level has been set too high. The management unit would first try to meet the goal exactly. If unable to do so, with a minimized weight deviation from all goal levels, it would be more likely to fail to meet that particular goal because it would be penalized less for being under as opposed to being over in the production of that goal. If $W_k^- << W_k^+$, the specified goal level would tend to function as a quasi-upper bound (Figure 5), in other words the organization would strongly prefer underproduction to overproduction. As W_k^- approaches zero from a positive direction, the goal, G_k, approaches the function of that of an upper bound. When $W_k^- = 0$, then G_k would in fact be an upper bound for the goal level production.

A similar argument can be made for $W_k^-/W_k^+ > 1$. This carries the meaning that the goal level has been set too low. G_k would function as a quasi-lower bound (Figure 6), and if $W_k^+ = 0$, G_k would function as a lower bound. It must be remembered that as long as both W_k^- and W_k^+ are greater than zero, the management unit will attempt to meet the specified goal level exactly.

When the weighting factors are viewed by the central unit, it must first decide what function the goal levels will serve:

1. Lower Bound
2. Upper Bound
3. Acceptable Range
4. Exact Goal Level Specification

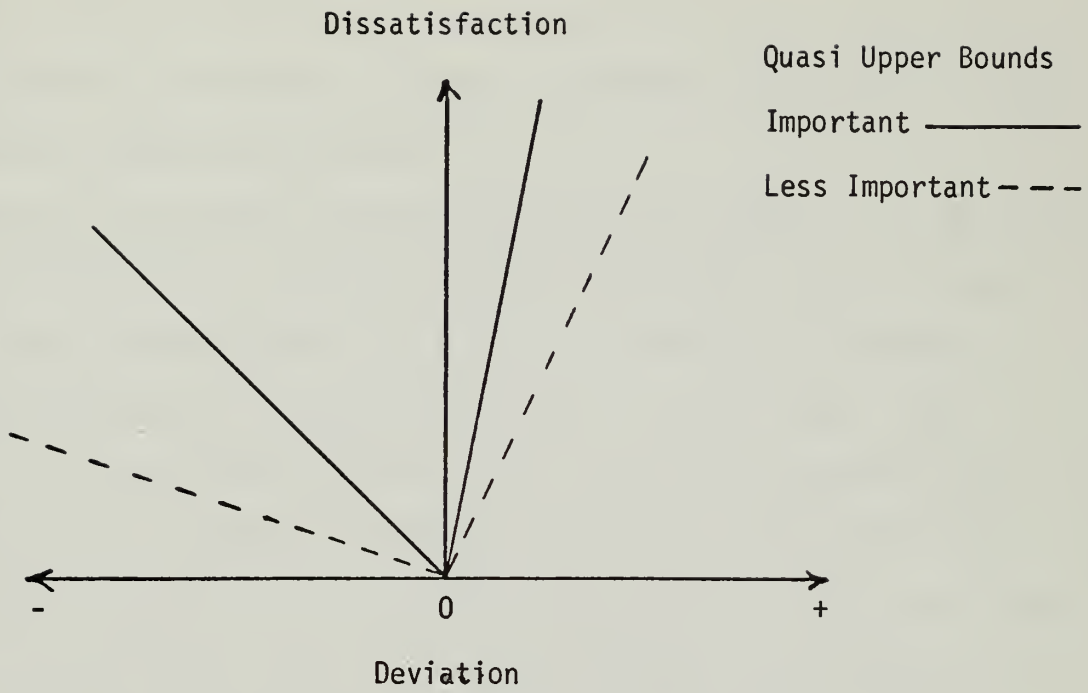

Figure 5

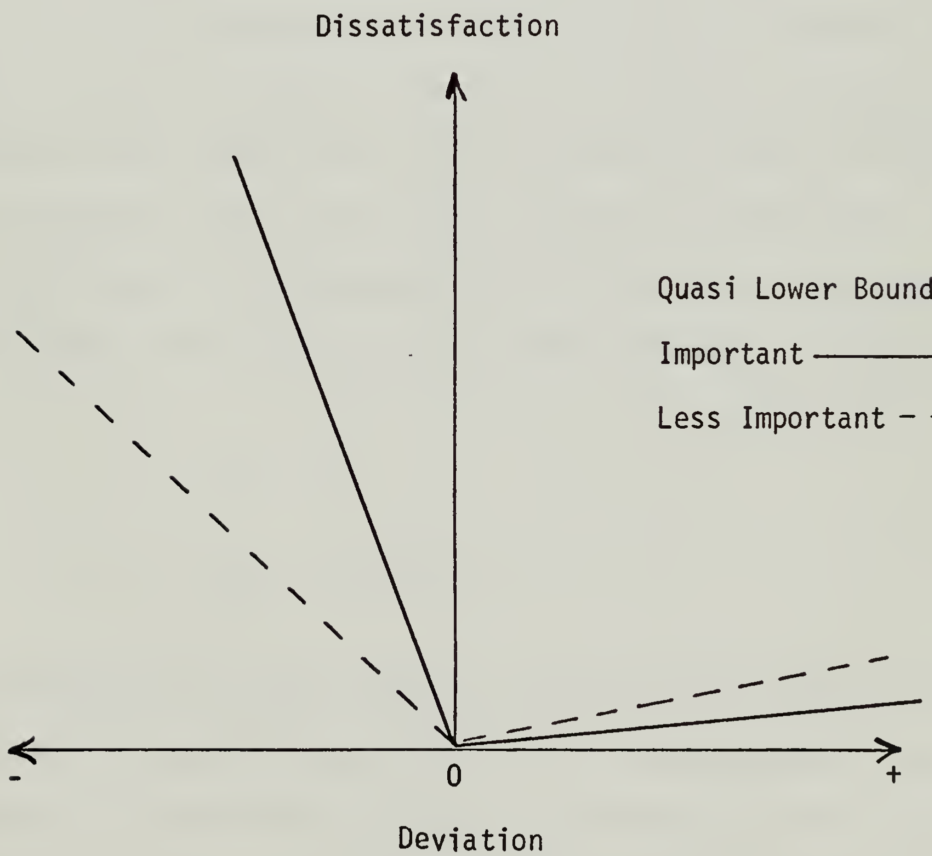

Figure 6

For cases 1 and 2, assigning the appropriate $W_k^{\pm} = 0$ will cause the goal to function as desired. For case 3, splitting of desired goal levels will accomplish the desired result.

For case 4, the central unit would like to see $W_k^- / W_k^+ = 1$ $(W_k^- = W_k^+)$ because it would believe that it had specified the goal level correctly. In this case, the organization would be just as badly off if the goal were underproduced as if it were overproduced. If $W_k^- \neq W_k^+$, the central unit would readjust the goal level until it was accurately set and $W_k^- = W_k^+$. The size of the weighting factors would reflect the priority of the central unit for not violating the goal. The size of the weighting factors would cause the minimized weighted sum of goal deviations to reflect the organization's "proper" priorities.

The management units assess weighting factors from their own parochial point of view. Each management unit has its own set of priorities for the goals which it is assigned. For goals it considers as high priorities, the management unit would like to have the weighting factors chosen so it could treat whatever goal level it was assigned as a lower bound. If not an exact lower bound, the management unit would prefer to have the weighting factors for its high priority goals function as a quasi-lower bound.

$$W_k^+ \to 0$$

$$W_k^- > W_j^- \quad \forall j \neq k$$

The management unit would suffer a relatively small penalty for overproduction and a relatively large penalty for underproduction. Then if it is unable to satisfy this particular goal exactly, it would tend to produce more of the goal since it is penalized less for exceeding the

goal than for failing to meet it. As such, the management unit will view whatever goal level passed down by the central unit for what it (the management unit) considers a high priority goal as a quasi-lower bound, i.e. it will tend to exceed the given goal level.

For what the management unit views as a low priority goal, a similar argument can be used with,

$$W_k^- \rightarrow 0$$

$$W_k^+ > W_j^+ \quad \forall j \neq k$$

The management units would like to have weighting factors so that if they are unable to meet the goal level exactly, they tend to present a solution that incorporates their own priorities — in other words, one which allows them to reorder the organizational priorities to be more in consonance with the priorities of the management unit.

V. METHODS FOR DETERMINING THE VALUES FOR WEIGHTING FACTORS

As has been shown in the preceding chapters, the solution is not only structure dependent, but also is a function of the weights assigned to the goal deviations. Ruefli has stated that the weights must be determined a priori. Before the model can begin to function these weighting factors must be assigned.

The simplest method of assigning values to the weighting factors ($W_k^{\pm}$) is to rank from low to high the preference or lack of preference for deviations from goals (that are as yet unknown) and assign weighting factors according to this preference ordering. The ranking could be done by either the central unit or the management units. But such a concentration of power to assign values to weighting factors disallows interaction between levels to determine weights. If the objective function for the central unit is not clearcut, but remains relatively unknown, the central unit would not have the necessary amount of information to make a determination that would be in the best interests of the organization. If the management units exclusively made the decision on the weights, they might not know the total picture or how the organization interfaced with its environment.

Ijiri [5] proposes what can be considered a three-step outline of a method for determining the value of the weights:

1. Determine if over/under production is satisfactory;
2. Rank the deviations into indifference classes;
3. Assign relative weights within indifference classes.

First, one must determine if over or under production is satisfactory. As a result of this decision, drop $Y_k^{\pm}$ from the functional. This is the same as assigning $W_k^{\pm} = 0$.

The decision here is similar to the decision as to what purpose the goal will serve:

1. Upper Bound ($W_k^- = 0$)
2. Lower Bound ($W_k^+ = 0$)
3. Exact Goal Specification ($W_k^+, W_k^- > 0$)

If the goals are to project the idea of an acceptable range, then it is necessary to decide on two subgoals, G_{k_L} and G_{k_U}, as lower and upper bounds.

The second step is that of ordering or ranking the deviations. For all $Y_k^\pm$ remaining in the functional, i.e. all $Y_k^\pm$ with $W_k^\pm > 0$, start from the positive or negative deviation which is least important, and continue ranking until one is achieved as "most important." This is a lexicographical ordering which indicates that the incompatible multiple goals are ordered so that goals of a lower rank are satisfied only after those in a higher rank are satisfied or have been satisfied as much as possible subject to the constraints. If a ranking determination between goals cannot be made, they are assigned to the same indifference class. M goals are now classified into K indifference classes.

Assign each variable in the j^{th} rank a "preemptive priority factor," M_j ($j=1,\ldots,k$) such that $M_{j+1} \ggg M_j$ ($j=1,\ldots,k-1$), i.e. no number n exists such that $n\,M_j \geq M_{j+1}$.[11]

If each goal belonged to a separate indifference class, the goal programing problem could easily be solved by building up sequential solutions. The goal with the highest rank would be satisfied as well as possible. Then one would go sequentially to the next lower ranked goal.

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[11]Ijiri, Y., Management Goals and Accounting for Control, p. 46, North-Holland Publishing Company, 1965.

Ijiri may need finer divisions for deviations because the orderings undertaken may depend upon the distances which remain for $Y_k^{\pm}$. He assigns pseudo goal levels in the form of a step function. When this idea is placed on a dissatisfaction-deviation diagram, it can be seen that it looks like a linear approximation to the Quadratic Goal Programing Form, as discussed in Chapter III. Figure 7 shows how a typical dissatisfaction-deviation diagram might look.

The third step is that of weighting the deviations. One must assign weights to deviations in the same indifference class. This weighting is determined by how much of an increase in a deviation would just offset a unit decrease in the deviation of another goal within the same indifference class. The object is to minimize the sum of the regret from all unsatisfactory achievement reflected in positive values for the slack variables (deviations) of the same indifference class. A positive weight is attached to the i^th^ slack variable when it appears in the objective function. This weight represents the relative amount of regret for one unit's unsatisfactory deviation from the goal level.

Choosing a numeraire $Y_k^{\pm}$ and letting it be Y_j:

$$(Y_j + \Delta Y_j,\ Y_i^z - 1) \text{ is indifferent to } (Y_j,\ Y_i^z) \qquad \forall\ Y_i^z \neq \text{numeraire}$$

$$i=1,\ldots,m \quad z=+,-$$

$$\alpha_i^z = \Delta Y_j$$

$$W_i^z = \alpha_i^z\,\alpha_j \qquad \text{where } \alpha_j \text{ is arbitrary positive value}$$

So one must force, in some sense, the deviation from the goals in the same indifference class to be commensurable. If an objective measurement is not available, a subjective decision must be made so that relative weights can be assigned to the deviations.

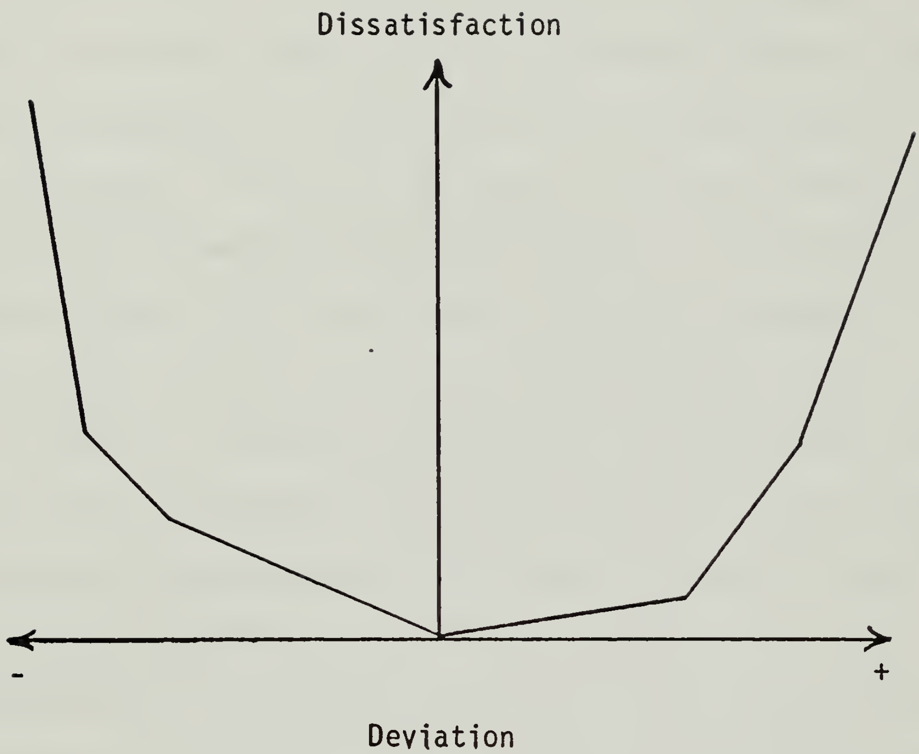

Figure 7

It is possible to postpone the weighting by solving the problem with equal weight given to every deviation in the same indifference class. If the deviations in the "solution" are zero, then the weighting is of no concern. If one variable in the group is positive, it implies that every variable is positive and therefore all must be weighted.

Gradual refinement of the weights is acceptable if there is explicit knowledge of the objective function and the constraints (goals). This may not be the case. If there is an iterative process in which the goals and the objective function may be modified (as in the Generalized Goal Decomposition Model), this would probably force the assignment of all weighting factors in order to give the model some common value on which to base a "decision." Generally this approach helps determine whether the goals within indifference class are compatible. If all the goals were compatible, then there would be no need for weights. In fact there would be no problem of allocation of scarce resources.

The coefficients of the objective function are a combination of pre-emptive priority factors and weights. It would appear that a substantial portion of the problems facing decision making organizations tend to have a very small number of indifference classes ($K \to 1$) and a larger number of members of the indifference classes. Even though there are some problems where exactly satisfying one goal is preferred to an infinite deviation from another goal, the discussion here will be restricted to the investigation of those organizations that can classify deviations from goals into only one indifference class, that is, lexicographical ordering will be ignored.

Ijiri's method requires explicit knowledge of the objective function and the goals to be achieved. He would even prefer trial runs to

determine if weighting is necessary. Ruefli's Generalized Goal Decomposition Model requires that weights be determined a priori, i.e. without any knowledge of the goal levels or organization. Ijiri's method would require trial runs for successive refinement of weighting factors and would be complicated in a model that progresses by iterations.

In order to derive a solution to an incompatible multiple goal system, one must order and weight under- and overproduction of goals in terms of preferences from the viewpoint of the overall organization's operations. These weighting factors are subjective and reflect how the organizational hierarchy feels about the goals of the organization and the interaction of the organization with its environment. Goals must be satisfied as much as constraints allow. Considering all interactions permitted by the constraints, the optimal solution is reached in accordance with the orderings and weights assigned to the various goals.

VI. FORMULATION OF A GOAL PROGRAMING METHOD FOR DETERMINING WEIGHTING FACTORS

In previous chapters it has been shown how Ruefli's Generalized Goal Decomposition Model functions and eventually reaches an optimum solution. However, the resulting solution is a function of the weights assigned to deviations from the organizational goals. The solution obtained is determined by the smallest possible weighted sum of goal deviations. The weights can be considered as the way in which the goals are viewed by the organization. In many organizations the weights are determined by interactions between managers and the central unit.[12] The model presented assumes that the managers prefer weights they feel favor their interests or that reflect what they perceive to be the actual situation; while the central unit with its overall view of the organization and especially its view of how the organization fits into its environment, may want to assign different values. As a hedge against uncertainty, the weights are determined by interactions as the organization builds up its objective function.

How exactly is this done? Ijiri's 3-step method has been discussed. This method tends to have one level, be it the central unit or the management unit, assigning the values for weights.

Since the organization reaches its decisions through the use of a goal programing technique (once the weights are known), it seems that a similar method would be used to determine the weights. Such a goal programing method allows for interactions between managers and the central unit which eventually determine the weights for the deviations.

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[12] Smithies, op. cit., p. 7.

To formulate such a model several assumptions will be needed :

1. That only the central unit and the management units are involved in determination of the weights to be used. This agrees with what Smithies [9] has said regarding the interplay that determines the weighting factors.

2. That a pseudo level exists between the central unit level and the management unit level which shall be called the "conference level." This level contains any number of "conference groups." These conference groups are the tools that determine the optimum weights via a goal programing technique.

The conference group receives inputs from both above (central unit) and below (management units) in the form of goals, H_k, and proposals, $B_{j,k}$. The conference group(s) minimize the sum of the deviation between the elements of the goals, H_k, and the optimum mix of proposals from the management units $\left[B_{j,k}\right]\left[x_{j,k}\right]$ by the choice of the activity level vector $\left[x_{j,k}\right]$. The formulation for the goal programing problem at the conference group level would look like the following :

j^{th} Conference Group

Primal

$$\text{minimize} \quad \underset{1\times n_k}{[0,\ldots,0]} \underset{n_k\times 1}{\left[x_{j,k}\right]} + \underset{1\times 2m}{[1,\ldots,1]} \underset{2m\times 1}{\left[Z_k^{+}\right]} + \underset{1\times 2m}{[1,\ldots,1]} \underset{2m\times 1}{\left[Z_k^{-}\right]}$$

$$\text{subject to} \quad \underset{2m\times n_k}{\left[B_{j,k}\right]} \underset{n_k\times 1}{\left[x_{j,k}\right]} - \underset{2m\times 2m}{\left[I_{m_k}\right]} \underset{2m\times 1}{\left[Z_k^{+}\right]} + \underset{2m\times 2m}{\left[I_{m_k}\right]} \underset{2m\times 1}{\left[Z_k^{-}\right]} = \underset{2m\times 1}{\left[H_k\right]}$$

$$0 \le x_{j,k} \le 1$$

$$Z_k^{+}, Z_k^{-} \ge 0 \qquad \forall k$$

$$Z_k^{+} \cdot Z_k^{-} = 0 \qquad \forall k$$

j^{th} Conference Group

Dual:

$$\text{maximize} \quad \overset{1 \times 2m}{\left[\; H_k^{+} \;\right]} \quad \overset{2m \times 1}{\begin{bmatrix} \Psi_k \end{bmatrix}}$$

$$\text{subject to} \quad \overset{n_k \times 2m}{\begin{bmatrix} B_{j,k}^{T} \\ \\ \end{bmatrix}} \quad \overset{2m \times 1}{\begin{bmatrix} \Psi_k \\ \end{bmatrix}} \quad \leq \quad \overset{n_k \times 1}{\begin{bmatrix} 0 \\ \vdots \\ 0 \end{bmatrix}}$$

$$- \overset{2m \times 2m}{\begin{bmatrix} I_{m_k} \\ \end{bmatrix}} \quad \overset{2m \times 1}{\begin{bmatrix} \Psi_k \\ \end{bmatrix}} \quad \leq \quad \overset{2m \times 1}{\begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}}$$

$$\overset{2m \times 2m}{\begin{bmatrix} I_{m_k} \\ \end{bmatrix}} \quad \overset{2m \times 1}{\begin{bmatrix} \Psi_k \\ \end{bmatrix}} \quad \leq \quad \overset{2m \times 1}{\begin{bmatrix} 1 \\ \vdots \\ 1 \end{bmatrix}}$$

Ψ_k unrestricted

Ψ_k positive → over produced H_k

Ψ_k negative → under produced H_k

$x_{j,k}$ is a 1 x n_k vector of activity levels associated with the proposals submitted by each of the n_k management units.

H_k is a 2m x 1 vector of central unit's choice of values for weighting factors for m goals.

$B_{j,k}$ is a 2m x n_k matrix where each column is a proposal from one of the n_k management units.

Z_k^+ is a 2m x 1 vector of positive deviations of the proposals from the goals (central unit's choice of values).

Z_k^- is a 2m x 1 vector of negative devaitions.

I_{m_k} is a 2m x 2m identity matrix.

Ψ_k is a 2m x 1 vector of shadow prices.

The goals H_k that appear in the formulation are now only the central unit's choice of values for weighting factors. The proposals sent up to the conference group by the management units are now proposed values for the weighting factors. Thus the goals are now the central unit's choice of weights while the proposals are the managers' choice of weights. The individual elements of the activity level vector, $x_{j,k}$, are allowed to lie anywhere in [0,1] in order to escape the integer programing problems that arise. (Ruefli uses this same technique in his GGD model.)

The shadow prices, Ψ_k, determined in the solution to the dual problem are passed up to the central unit and down to the management units. They are a measure of the relative satisfaction of the goal, and, as in Ruefli's GGD model, they drive the system. A negative shadow price means that the value of the weighting factor proposed by the management unit is below the value of the weighting factor as proposed by the central unit. A positive shadow price is synonymous with the value of the weighting factor proposed by the management units being greater than the value proposed by the central unit. The range for these shadow prices is [-1,1].

Note that the weights for the components of the conference group objective functions are all equal and set to a value of one. This says that the deviations from any goal (value for weighting factor) are

considered of equal importance when the attempt is made to minimize goal deviations. The actual number or value assigned to the weighting factors (to be determined by solving this problem) are the measures of the accuracy/priority of the goal levels used in the decision making organization. In the author's opinion, it is equally important to the conference group and to the organization as a whole that every weighting factor be properly chosen since the weighting factors should reflect accurate information. Thus there is no need to weight the weights, since "correct" weights are equal in importance to the functioning of the organization.

The number of conference groups is up to the central unit. But the choice of the number and composition of the conference groups is similar to the choice of the organization structure in the GGD model. And as such it has the same effect as in the GGD model on the final solution.

The central unit maximizes the inputed values of the weights. It will tend to reduce the weights, the appropriate elements of H_k, that have not been met by the conference group solution as determined by those elements with negative shadow prices. It will tend to increase those weights that have been exceeded in the conference group solution, i.e. those goal elements (weights) that have a positive shadow price. The constraints that appear at the central unit level contain information regarding the priority of the goals and the purpose of the goals. (See Chapter IV.) These constraints tend to prevent the assignment of weights that the organization considers as ridiculous. They would also tend to insure that the weighting factors for high priority goal deviation would be larger than those assigned for low priority goal deviations.

This model assumes that the central unit is very responsive to the decisions of the conference groups because its objective function is

formed from the inputs it receives from all the conference groups. It then modifies its choice for weights, H_k, in an attempt to decrease the deviations of the conference groups.

Central Unit

$$\text{maximize} \quad \sum^{N} \underset{1\times 2m}{[\Psi_k^T]} \underset{2m\times 1}{\begin{bmatrix} H_k \end{bmatrix}}$$

$$\text{subject to} \quad \sum^{N} \underset{p\times 2m}{\begin{bmatrix} E_k \end{bmatrix}} \underset{2m\times 1}{\begin{bmatrix} H_k \end{bmatrix}} \leq \underset{p\times 1}{\begin{bmatrix} W_o \end{bmatrix}}$$

$$H_k \geq 0$$

N = # of conference groups

The management units are unique in that they have two often opposing views to follow. The problem is: how do they implement the decisions reached by the conference group and passed down to them in the form of shadow prices, and still follow their own views as to how a specific goal should be treated. The problem will be biased toward one or the other of the competing loyalties depending on the structure.

If the management unit's views are neglected it becomes completely subservient to the central unit constrained only by its more detailed knowledge of its area of interest. It would become an "organizational yes man." If the guidance (desires) of the conference group were neglected, the management unit might act at cross purposes with the conference group and hence with the organization itself.

This problem can be handled by constructing a composite objective function such that one part acts in consonance with the desires of the conference group while the other part includes the management unit's own biases. It was decided to include a weighting variable, ϕ , as a multiplicative coefficient for the bias portion of the objective function. By allowing this coefficient to vary from 0 to 1, the management unit's behavior would vary from that of being completely subservient to that of allowing its own bias to fully enter and be a factor in determining the proposed weighting factors. The portion of the composite objective function that executed the decisions of the conference group was always present because the model assumes that a subordinate in a decentralized organization must always consider the wishes of his superiors. Behavior to the contrary would not be consistent with the model's assumptions. Hence the conference group portion of the composite objective function would always be present.

The formulation of the management unit's problem can be seen below. The first portion of the objective function is the conference group portion. Utilizing the shadow prices passed down from the conference group, the management unit would increase the weights with a negative shadow price and decrease those with a positive shadow price. Thus the management unit attempts to generate new proposals (weights) which help minimize the sum of the deviations. The second portion of the objective function indicates the bias of the management unit. The bias portion has a multiplicative coefficient, ϕ , which determines the amount of bias that the management unit allows to influence its objective function. In the minimization problem, the bias vector tends to force the weights so that what are

considered by the management unit as high priority goals will have weights which tend to act as lower bounds, and low priority goals will have weights which tend to act as upper bounds.

j,k^{th} Management Unit

$$\text{minimize} \quad \overset{1\times 2m}{[\ \Psi_k\ ]} \overset{2m\times 1}{\begin{bmatrix} B_{j,k} \\ \\ \\ \end{bmatrix}} + \phi \overset{1\times 2m}{[\text{Bias Vector}]} \overset{2m\times 1}{\begin{bmatrix} W_1^{+} \\ W_1^{-} \\ \vdots \\ W_m^{+} \\ W_m^{-} \end{bmatrix}}$$

$$\text{subject to} \quad \overset{R\times 2m}{\begin{bmatrix} C_{j,k} \\ \\ \end{bmatrix}} \overset{2m\times 1}{\begin{bmatrix} B_{j,k} \\ \\ \end{bmatrix}} \geq \overset{R\times 1}{\begin{bmatrix} D_{j,k} \\ \\ \end{bmatrix}}$$

$$B_{j,k} \geq 0$$

where $B_{j,k}$ is a proposal made up of a selection of weights $W_k^{\pm}$

<u>[Bias Vector]</u>

If i^{th} goal component of original organizational decision problem has a high priority for the j,k^{th} management unit, the management unit desires that the weights serve as a Lower Bound

$W_k^{+} \rightarrow 0$

W_k^{-} Large

i^{th} pair in the bias vector would be

[1 -1] since a minimization problem forces W_k^{+} to be smaller and W_k^{-} to be larger.

If i^{th} goal component of original problem has a low priority for the j,k^{th} management unit, weights should serve as an Upper Bound

W_k^+ Large

$W_k^- \rightarrow 0$

i^{th} pair in the bias vector would be

$[-1 \quad 1]$ since a minimization problem would force W_k^+ to become larger and W_k^- to become smaller.

The constraints found in the management unit problem would contain restrictions based on information passed down from the central unit in the initial seed to start the iterative process. The information would be in terms of organizational ground rules and broad organizational goals. It might also contain information pertaining to restrictions on feasible (acceptable) choices of weights and any internal technological goal coefficients.

By allowing ϕ to vary from 0 to 1, this weighting model could be used in a sensitivity analysis to determine the robustness of the weighting factors model. It would be a surrogate to seeing how the behavior and/or attitudes of the management unit affects the choice of weighting factors. It would be useful in determining the breakpoint in the attitude of the management unit as this affects the choice of organizational weighting factors. It should be noted that the first part of the composite objective function would become the numeraire in the sensitivity analysis so the robustness of the model would be indicated in terms of conference group standards (or subservient behavior on the part of the management unit).

If it were thought that running a sensitivity analysis on the full range of ϕ was too time-consuming or computationally difficult, the value

for ϕ could be an arbitrarily assigned value based on a perception of how it was thought that the specific management unit would act when faced with conflicting views.

A possible area for further extension of the proposed model is the incorporation of a central unit that has the same conflicting views as do the management units. The central unit may believe in its own version of H_k to such a degree that it has to reconcile its prejudices with the conference group results.

VII. SUMMARY

In this thesis Ruefli's Generalized Goal Decomposition Model has been expanded to include a goal programing method for determining weighting factors using a separable objective function for the management units, which includes both an organizational portion and a subordinate bias portion. Some necessary restrictions on the choice of weighting factors were discussed. The Generalized Goal Decomposition Model was extended to include quadratic deviations from goals, and the function of shadow prices was compared with the linear deviation formulation. The interpretation of weighting factors was viewed in the context of a contemporary organization. A discussion was conducted of some of the current methods for determining weighting factors including that of Ijiri. The proposed goal programing model for determining weighting factors was intended to complement Ruefli's model. Together these models were better able to represent an organizational decision process. A sensitivity analysis on the subordinate bias portion of the management unit level of the model would help determine the robustness of the model.

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13. ABSTRACT

A review of some of the current thinking pertaining to suboptimization and decentralization is conducted. Ruefli's Generalized Goal Decomposition Model is discussed with emphasis placed upon description of the informational requirements necessary for the iterative process and the constraints necessary for the model to function. The Generalized Goal Decomposition Model is extended to include quadratic deviations from goals. The nature of weighting factors in an organizational context is examined. Some current methods for determining weighting factors for goal programing problems are presented. A goal programing method using a separable objective function for the management level is proposed for determining weighting factors.

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